The visits to the flowers with partially apparent honey $a + b$ steadily diminishes from the Tenthredos to Andrena and Halictus, but so that the diminution of the visits entirely refers to the flowers with the honey apparent, while, on the contrary, the flowers with honey partially hidden are visited with still greater frequency.

In the case of some solitary bees, the disinclination to flowers with the honey apparent has reached to their total abandonment.

The transition to social life brings the development in the second group, of which we have been treating, to an end, as, in proportion as the number of individuals in a community increases, the necessity for food forces them to seek honey where they can, and it is indeed touching to see the unwearied diligence with which the hive-bee will collect almost imperceptible drops of honey from even the smallest flowers.

The perfection which the family of bees, viewed as a whole, has attained, beginning with Prosopis, and rising to the most perfect of the solitary bees belonging to the group which collect pollen on their hind legs, consist :—

1. In the increasing development of the pollen-bearing apparatus.
2. In the prolongation of the lower part of the mouth.
3. In the increasing size of the individuals.

The first is seen best in the humble and hive-bees ; the third is very marked in the humble-bee, while the length of the proboscis reaches its furthest point in Anthophora. The hive-bee has a more perfect pollen apparatus than the humble-bee, but is inferior to the latter in size and length of proboscis, and only succeeds in obtaining more honey through its more populous communities.

It is well known that as a rule every hive-bee occupied in seeking food from flowers specially devotes itself to a particular species, passing by others, however rich in pollen or honey. The advantages of this arrangement are obvious, much fewer visits being made in vain to flowers already plundered, and much greater dexterity being attained in the case of flowers with complex forms.

Two questions remain to be decided—

1. Does each individual bee collect pollen and honey from a single plant only (to which it has become adapted by instinct, *i.e.*, by inherited custom)?
2. Does the hive-bee possess a greater degree of intelligence in deciding among the different species of plants than the humble-bee and other lower forms?

The first question must be met with a decided negative ; the second, as far as observation has yet gone, cannot be answered with certainty. It would scarcely be of advantage to the bee-community, whose object is the exploitation of as many flowers as possible, if its instincts as to special tribes were hereditary.

It is, on the contrary, to be observed in the hive-bee that each bee makes various essays before deciding on any special tribe of flowers. For example, we have seen a hive-bee in vain attempt to obtain the honey of *Iris pseudacorus*, and then fly to *Ranunculus acris*, which it sucked at for some time. Another more than once bored through the spur of *Orchis latifolia*, loading its head with two little clubs of pollen, and then flying to the flowers of *Lychnis floscuculi*.

A third, wandering over a field full of weeds, visited one after another *Veronica hederæfolia*, *Lithospermum arvense*, *Sisymbrium thalictrum*, and *Viola tricolor*.

These and similar facts show that there can be no question of inherited preferences for certain plants in individual bees, and that the fact of each bee being devoted to certain plants is only to be ascribed to the subordination of the interests of the individual to that of the state. The humble-bee approaches the hive-bee in the peculiarity of keeping to certain species, as well as in the number and keeping of its community. However, though chiefly confining itself to the plants accessible to it alone, as for example, *Lamium album*, &c., there are fairly numerous cases in which the humble-bee goes to other plants, and its baskets are often found full of very varied kinds of pollen.

Even in solitary bees, the special preference for special kinds of flowers is a frequent habit. For example, *Andrena hattorfiana* is found on *Scabiosa arvensis*, *Cilissa melanura* on *Lythrum salicaria*, &c. ; but this preference evinced by some solitary bees for a single species of flower sufficing all their needs is radically different from the practised and exhaustive pillage of all flowers by a bee community, in which special individuals are told off to gain the produce, however small, of special families of plants. At first I believed I could answer the other question propounded above, *i.e.*, whether the hive-bee promises a higher degree of intelligence in distinguishing different genera of plants than the humming-bee and other lower forms, in the affirmative, on the ground of the following observations :—In a field grown over with weeds I saw one of our more intelligent humble-bees, *Bombus agrorum*, visit without distinction the little whitish flowers of *Viola tricolor* var. *arvensis*, and those of *Lithospermum arvense*, the same size and colour, but evidently differing in form, while avoiding all other plants. I had, indeed, seen the hive-bee mistake the flowers of *Ranunculus arvensis* for those of *R. bulbosus*, those of *Trifolium repens* for those of *Trifolium fragiferum* many times, but had then never seen it make so great a mistake as that I have recorded of the humble-bee. From this I concluded that the hive-bee is more practised in distinguishing various species than the humble-bee. As, however, I later saw the hive-bee go from the blue violet to a hyacinth of the same colour, and back again, I felt convinced that the grounds of my conclusion were somewhat defective, and I can only leave the decision of this question to further observations. As far as my own experience is concerned, I am inclined to believe that the hive-bee, as well as all other bees which we see preferring special families of plants, are much more led by colour and size than by any clear apprehension of the form of the flowers.

A. J. G. D.

AN ACCOUNT OF DUPLEX TELEGRAPHY

THE introduction of the duplex system of working not only upon land-lines, but on sub-marine cables, is without doubt the most important advance recently made in electric telegraphy.

Duplex telegraphy may be defined as the art of telegraphing in opposite directions simultaneously along one line wire.

It is claimed by M. Zantedeschi in papers read before the Academy of Sciences, Paris, in 1855, that as early as 1829 he had suggested and demonstrated the possibility of working "duplex;" but until the year 1853 there do not appear to have been any noteworthy attempts made to effect it practically. In that year, Dr. Gintl, a director of Austrian telegraphs, described a system of duplex telegraphy to the Academy of Sciences, Vienna, and practically tested it on the land-lines between Vienna and Prague.

The principle underlying this and all other systems, is that the outgoing currents at a station shall not sensibly affect the receiving instrument there, while, at the same time, the latter is free to be affected by the incoming currents, so to speak, from the other station. That is to say, no signals are made at a station by its own sending currents, unless when these are interfered with by the sending currents of the other station.

Gintl's plan was as shown in Fig. 1. The receiving instrument, R I, was wound by two separate wires, one long and thin, the other short and thick. The long wire, shown by a full line, was connected at one end to the line L, and the short wire, shown by a dotted line, was connected at one end to a local, or, as it was called, a "com-

pensating" circuit. Both of these wires were connected at their other ends to a signalling key or sending instrument, K, having duplicate points. Two batteries, B and B′, one large and the other small, were also connected to this key in such a manner that on making contact the current from the larger battery B passed through the long coil of the instrument into the line, while at the same instant the current from the smaller battery B′, passed through the short coil and compensating circuit. These two currents were so adjusted as to balance each other in their effects on the indicator of the receiving instrument, and no signal was therefore made by the outgoing or signalling current from the battery B. Such was Gintl's arrangement at both stations, S and S′. Confining our attention to any one of these stations, say S, we see that as long as only S is sending, the receiving instrument at that station is unaffected, but when S′ is also sending at the same time, the currents in the line from S′ must interfere with the currents in the line from S, either aiding or opposing these according to the poles of the battery which are applied, and thereby disturbing the balance of currents on the receiving instrument at S, causing it to make signals. And we see also that these signals are entirely under the control of S′—that when S′ applies his battery to the line, S's instrument will make a signal, and that when S applies his battery to the line, S″s instrument will make a signal, or that when either put "earth" to the line, that corresponding "spaces" will be recorded. The currents do not cross each other in the line, as was sometime thought, but they interfere with each other in such a way as to disturb the electric balance which independently exists at either end.

One objection, however, to this plan of Gintl's was that the lever of the key during sending interrupted the line circuit when it was between the earth and battery contacts; and another more serious objection lay in maintaining the equivalence of the two currents, as the smaller battery working through the shorter circuit lost power more rapidly than the signalling battery.

Gintl, however, in the following year (1854) obtained better success with a Bain's chemical printing instrument. Here he made the two currents oppose each other upon the chemically prepared paper and no stain was produced by the outgoing current. The sending current from the other station neutralised to a certain extent the outgoing current and the *local* current then overmastering it stained the paper and produced signals.

Early in 1854, while Gintl was still engaged in experimenting with the Bain's instrument, a great improvement was effected on his plan by Herr Carl Frischen, a telegraph engineer of Hanover. Frischen dispensed with the second battery B′ and split up the signalling current itself, causing one part to pass round one coil of the receiving instrument into the line and the other part to pass round the other coil of the instrument into the local or compensating circuit. Instead of making the two wires of the instrument dissimilar, like Gintl, he made them both alike, so that the instrument was practically wound by equal wires in opposite directions and thereby rendered *differential*. He inserted into the compensating circuit a rheostat or set of resistance coils whose resistance could be adjusted to equal the electric resistance of the line. His arrangement at either station is shown in Fig. 2. Here R I is the differentially wound receiving instrument, B is the battery, and R is the rheostat or artificial line as it was called, because of its being intended to imitate the actual line. K and E are as before, the sending key and earth plates respectively. In the act of sending a message, on making contact between the key and battery at a the current flowing into the apparatus divides itself at the point b, and part passes through the right coil of the instrument into the line, while part passes through the left coil into the local circuit. But the resistance of the local circuit being made equal to that of the line and the two coils of the instrument being electrically equal one *half* of the current will flow through one coil and the other *half* through the other coil. The coils being oppositely wound these currents will neutralise each other in their effect on the indicator or needle of the instrument and no signal will be produced as long as they flow freely. We have seen, however, that the sending at the remote station may either oppose or assist that part of the current entering the line. Thus the balance is disturbed and signals will be made on the receiving instrument of one *kind* or another according as the line current or the local current overbalance each other.

In sending by this method of Frischen's the line circuit is never completely interrupted, but it will be observed that according to the position of the key the line is either applied "to earth" direct or through the battery, or through the resistance R, and this leads to a troublesome variation in the signals.

Frischen's method was re-invented a few months subsequently by Messrs. Siemens and Halske of Berlin, who patented it in England, where, however, they were forestalled by a week by Mr. Stirling Newall, of Gateshead, whose patent bears date October 30, 1854. Newall describes substantially the method of Frischen–Siemens, and in 1855–56, successful experiments were made under his patent on the Manchester and Altringham line; but when he came to make trials upon the longer line between Birmingham and London, the *static* charge and discharge of the line was found to make false signals. Condensers or accumulators of electricity were applied to correct this disturbance with promising results, but the expense of constructing large condensers was objected to and their use was prematurely abandoned.

At this time there was a great deal of activity in the direction of duplex working displayed both at home and abroad. Besides the names mentioned, Messrs. W. H. Preece, Highton, De Sauty, and others in this country, Edlund, Bosscha, Kramer, in Germany, and Farmer, in America, were all more or less engaged in the work. In 1856 a good many lines were worked on the duplex principle in Prussia, but the time was not yet ripe for its successful introduction, and it gradually fell into disuse again. Some desultory activity was still shown here and there, however, showing that the idea had not been lost sight of. In 1862 Mr. William Hinckling Burnett patented a method of working two or even three distinct systems of telegraphy by the use of currents of different degrees of force, and in 1863 M. Maron, of Berlin, appears to have first placed the receiving instrument in the diagonal of a Wheatstone's balance. This has been called the Wheatstone bridge method in the recent revival of duplex, and it may be shown as follows, Fig. 3.

Here r and r' are two of the branch resistances of a Wheatstone's balance; the line and artificial line, or rheostat, R, forming the other two branches. The receiving instrument, R I, is inserted in the "bridge" wire. In sending, the current from the battery B splits at b, and part passes by r into the actual line, while part passes by r' into the artificial line. If r be equal to r', and the actual line be equal to the artificial line, the current will divide itself equally, and the potentials, or, as it may be called, the electric levels, at c and d, will be equal, and there will be no tendency for a current to flow through the cross channel or "bridge wire," and the receiving instrument will not, therefore, be affected. When, however, the line currents are interfered with by the sending currents of the distant station, this balance will be disturbed, currents will flow through the "bridge wire," $c\,d$, and the receiving instrument will signalise. The resistance, w, may with some slight advantage be made equal to the battery resistance. It will be seen that in the balance method, as in the differential method, the principle consists in dividing the signalling current between two circuits whose electrical properties are practically the same,

and so placing the indicator between these as to cause them to neutralise each other's effect upon it.

The credit of reviving the lagging interest in duplex telegraphy appears to be due to Mr. Joseph Barker Stearns, of the Western Union Telegraph Company, United States, who, in 1868, experimented on the New York to Boston line, and subsequently achieved considerable practical success on the overland lines of the company with which he was connected. In 1872 Stearns came to England and patented his system, which practically embraced the differential and Wheatstone balance methods, as described, with the addition of a novel sending key and a condenser attached to the rheostat or artificial line.

With the differential method his arrangement is as shown in Fig. 4, where K is the new sending key, and C is the condenser. The advantage of Stearns's key is that the manipulating lever, *a* (which is permanently connected to the battery B), makes contact with the lever *b* (which is permanently connected to the receiving instrument), before *b* is disconnected from the earth wire *w*, so that, in sending, the line may always be "to earth,"

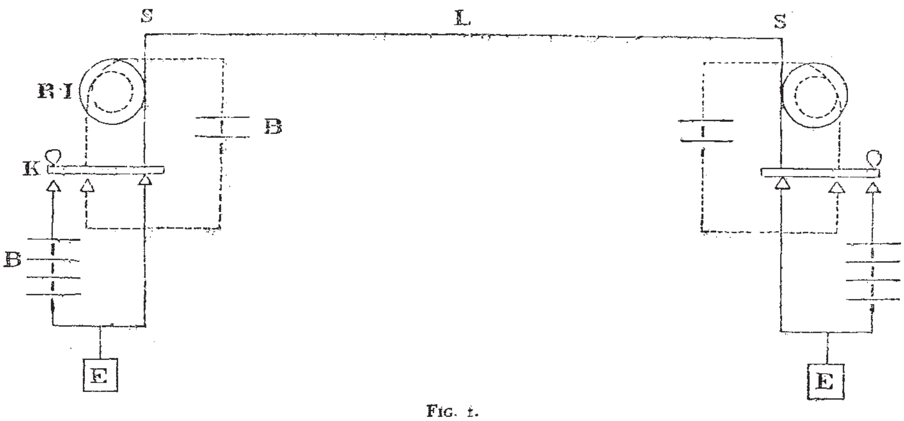

FIG. 1.

either through the battery B, or the earth wire *w*. Thus the evils of both Gintl's and Frischen-Siemens's methods are obviated, inasmuch as the line circuit is not only never interrupted, but the resistance of the earth connection may be kept the same by keeping *w* equal to the resistance of the battery. In order to prevent the wasting of the battery while it is short-circuited for a moment through the key, the resistance, *w'*, may be added to the battery resistance, and *w* then made equal to both.

The condenser was applied, as in the experiments made under Newall's patent, to correct the effects of the static induction of the line upon the instrument. Condensers or accumulators had been in common telegraphic use for producing induction since Bagg's patent in 1858 and

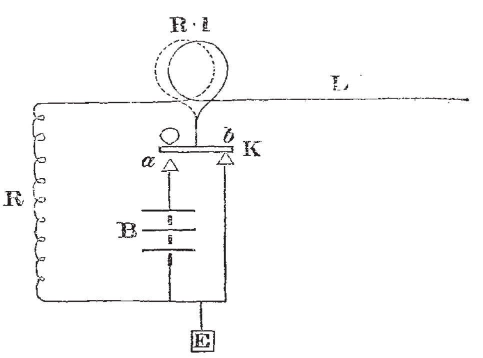

FIG. 2.

Varley's in 1860, and it is obvious that the sudden inductive charge and discharge of the line could be counterfeited by attaching a condenser or other inductive apparatus to the artificial line. This inductive effect is in general only sensible on land-lines upwards of 300 miles long. The induction between the wire and earth is then sufficient to maintain a sensible static charge on the wire, independently of the signalling *currents*, so that on working the sending key, and thus charging the line, the sudden static charge is for a moment added to the signalling current or dynamic charge; and, on the other hand, when the key is made to earth the line, this static charge flows back again out of the line to earth. Thus two sudden jerks or "kicks," as they are called, are produced on the electric balance, and false signals are thereby made. When, however, a condenser or other inductive apparatus is added to the artificial line, so as to give it induction, too, the charge and discharge "kicks" of the artificial line may be made to counterbalance those of the actual line. In short, it is clear that if the electrical properties of the artificial and of the actual line in induction, resistance, and insulation are approximately equal, a duplex balance can be effected between them.

Stearns's key and earth connections were subsequently

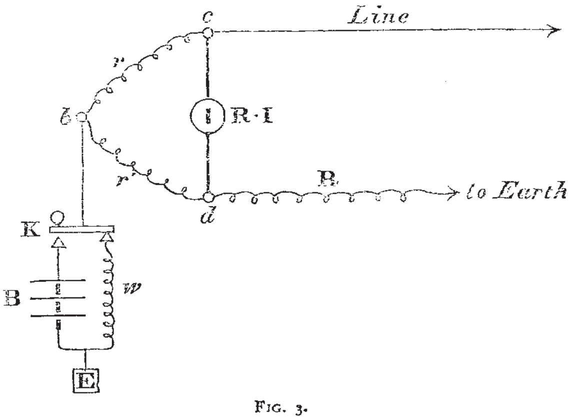

FIG. 3.

in the same year (1872) re-invented by Herr J. F. Naes, of Rotterdam.

In 1873 Mr. George Kift Winter, Telegraph Engineer of the Madras Railway of Arconum, British India, patented in England a method of duplex by opposed batteries, a principle which it appears had been previously applied by Mr. Moses G. Farmer, of New York, in 1858. Winter's method consisted in keeping the batteries at both ends of the line continually applied to it, so that their like poles opposed each other and a standing balance was maintained on the receiving instrument at either station,

which could be disturbed by the operator at the other station. This arrangement is shown in Fig. 5.

Here, as will be seen, the batteries are equal and are constantly connected to the line, so that their like poles oppose each other through the differential coils of the receiving instrument and the line. Thus the balance is maintained. But when at station S, for instance, contact is made with earth by the keys K, the battery B will be cut off from the line, and the current from station S', no longer opposed, will make a signal on the instrument there. Winter's method was tried with some success in India. Up to this time experiments had been for the most part confined to land-lines.

Attention now began to be turned to submarine cables, and Winter proposed the use of secondary batteries, made of plates of one metal (as lead) immersed in a single fluid (as sulphuric acid), in order to provide the large electric induction necessary to the artificial line, or by application in some particular way to the receiving instrument, so as to counterfeit the induction "kicks."

Stearns, also, in the same year, took out further patents principally for the purpose of extending his system to cable work. For example, he patented combinations of condensers and resistance coils to represent an artificial

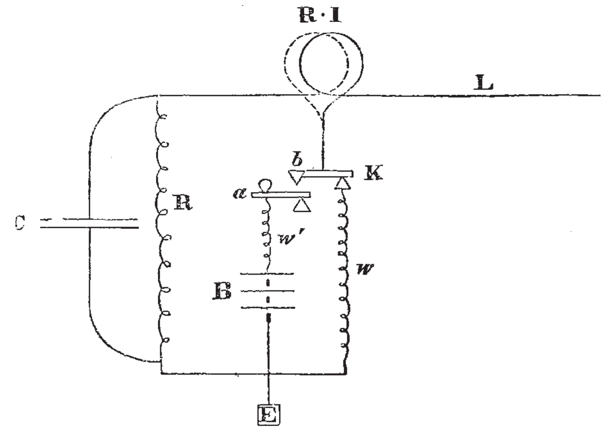

Fig 4.

cable. This, however, had been done as early as 1862

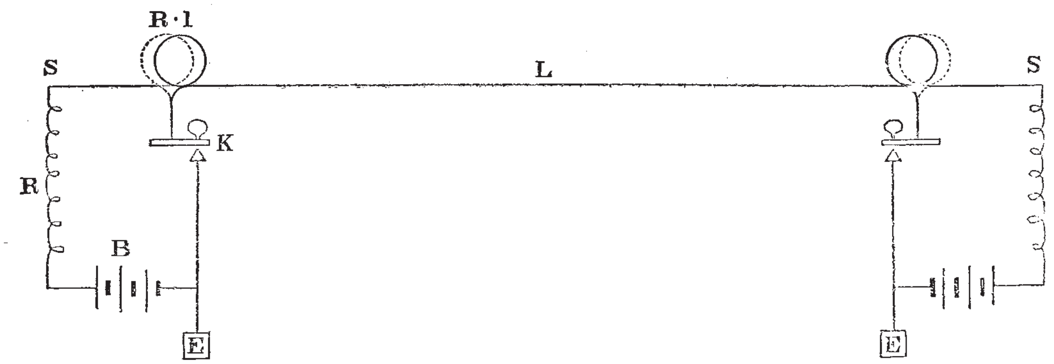

Fig. 5.

by Varley, for the purpose of making an imitation cable for use as a "test" circuit. Varley distributed his condensers along his resistance circuit in the manner shown in Fig. 6, so as to approximate to the uniform distribution of resistance and capacity in a submarine cable; but Stearns confined himself to attaching his condensers all at one point of his rheostat, and modifying their charges in various ways by means of resistance coils. Stearns also proposed various additional arrangements for superimposing "kicks" on the receiving instrument which should counterbalance the inductive "kicks" known to be very violent and difficult to obviate on submarine cables. He also describes a method of constructing his condensers in the form of a submarine cable; and, apparently for the purpose of economising material, he further proposes to employ Gintl's original plan of two

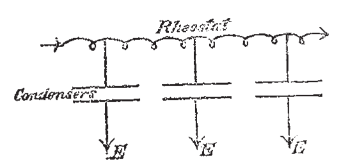

Fig. 6.

batteries; but in this case the stronger battery would be used to charge the artificial line, so that, with less capacity

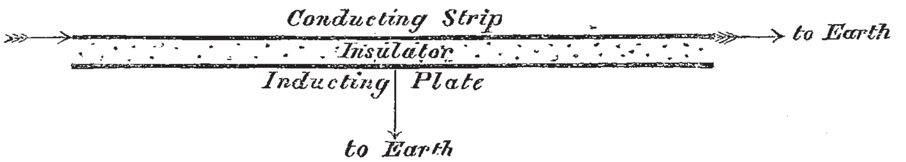

Fig. 7.

than the actual line, its inductive "kick" might be made equivalent to that of the latter. In fact, Stearns and Winter appear, naturally enough, to have striven rather to effect the duplex balance by some *device* or by an artificial line approximately *similar*, instead of aiming at one approximately *equal* to the actual cable.

In 1874 Mr. Louis Schwendler, of Calcutta, patented a system founded on the Wheatstone balance principle, and applicable to submarine cables by the use of resistance coils and condensers, or of a cable itself as an artificial line; but Schwendler's system is only novel for the ratios between the resistances of the balance which it lays down. The best results are said to be given when the resistances r', R and w, Fig. 3, are each one-half of the resistance of the line, and r is made equal to one-sixth of the resistance of the line.

The first successful trials in submarine duplex that we hear of are mentioned in the *Journal of the Society of Telegraph Engineers* for 1874. From this it appears that Messrs. De Sauty and Harwood, both of the Eastern

Telegraph Company (which had been encouraging experiments), had succeeded in effecting a balance, in 1873, on the Gibraltar-Lisbon cable by the use of the Wheatstone balance method and Varley's artificial line. Also, in a letter to the *Telegraphic Journal* for 1874, by Mr. B. Smith, of the Eastern Telegraph Company, we learn that he had succeeded in effecting a balance on one of the Company's cables between Malta and Alexandria in July, 1873, so that he could receive messages while sending a distance of 911 nautical miles. In September of the same year Mr. Smith also reported good success on the Malta-Gibraltar cable, a distance of 1,121 nautical miles. We are not aware, however, that these methods have been in practical working for any length of time.

In 1874 Mr. John Muirhead, of the firm of Messrs. Warden, Muirhead, and Clark, telegraph engineers, Westminster, took out a patent for a new form of condenser, or inductive-resistance, so made as to imitate a submarine cable, and ostensibly for the purpose of duplex telegraphy. The inductive resistance is formed by taking two strips of tinfoil and laying one over the other separated by an insulator. One strip forms the conducting circuit of the artificial line, the other forms the outer, or inductive coating, and is connected to earth. The current is passed through the conducting strip and exposed throughout its entire length to the induction of the other strip or sheet in the same way that the current in the conductor of the cable is subjected to the induction of the earth throughout its length. The principle of Muirhead's artificial line is shown in Fig. 7, where the arrows represent the local current passing along the conducting strip while being at the same time retarded by the induction of the other strip, or inducting plate, which is connected to earth.

This artificial, or model cable, can be made to have the same resistance, capacity, and even leakage, per knot, that the actual cable has, so that it can be made practically equal in its electrical properties to the actual cable. It may be employed either with the differential or Wheatstone balance methods. In either case the local current passes through the conducting strip to earth, experiencing the same resistance and retardation that the signalling current experiences in the cable. It therefore balances the signalling current in its effects on the instrument. Its advantage over Varley's "artificial line" consists in the closer equivalence to an actual cable that it admits of. Subsequent patents of Mr. Muirhead describe various adjustments to be used in connection with the artificial line for the purpose of refining upon the balance.

In July, 1875, this system, which is hitherto the most successful of all in submarine duplex, was first tried on the Marseilles-Bona (Algeria) cable, a length of 448 nautical miles. In the spring of this year it was established for permanent working on the Marseilles-Malta cables of the Eastern Company, a length of 826 nautical miles, and also on the Suez-Aden cable, a length of 1,461 nautical miles, but in an electrical sense, one of the longest of existing cables. These are the first practical successes in submarine duplex telegraphy, and they also prove the feasibility of working cables of any length by this advantageous method.

MUSEUM SPECIMENS FOR TEACHING PURPOSES[1]

II.

ARTICULATED or mounted skeletons are divided into two classes: 1. Natural; 2. Artificial. The two processes may, however, be more or less combined in certain cases.

Natural skeletons are not macerated. The bones are merely cleaned by the hand, assisted by scalpel, scissors, and brush; the subject being placed in water during the intervals of the operation, to get it free from blood, and to soften the parts removed. Everything having been taken away, except the bones and the ligaments which unite them, the skeleton is fixed in the required attitude by external supports, and allowed to dry. This process is commonly adopted with very small mammals, birds, reptiles, and especially fish. It has the advantage of involving less labour and skill in articulation, and of affording a trustworthy record of the number and relations of the bones, especially the vertebræ, about which, in an artificially articulated skeleton, unless prepared by very competent hands, there always may be doubt. On the other hand, such skeletons are far less useful for the study of the details of their structure, they not only cannot be taken to pieces, but the extremities of the bones are actually concealed by the dried ligaments. The latter, moreover, often become brittle with time; and in the case of the smaller specimens, will break unless handled with great care. In such cases it is often advisable to strengthen them with isinglass, or when more support is required, some strands of cotton-wool steeped in melted isinglass or glue make excellent artificial ligaments.

2. Artificial skeletons are those in which the bones have all been separated and completely cleaned by maceration, or one of the processes substituted for it, and then joined together again by wire. The reconstruction of such skeletons is technically called "articulating." To perform it properly some knowledge is required of osteology, so that the bones may be placed correctly, which of course is of the utmost importance, and also some mechanical skill in drilling the holes in the bones, and in adapting and fitting the wires and metal supports, and several instruments are required, not needed in the preparation of natural skeletons, such as drills, pliers, wire-cutters, files, &c.

The best wire is iron-tinned, which does not rust, and is now sold at most ironmongers. For very fine work, iron wire plated with silver, and for still more delicate operations, especially in fishes' skeletons, thin silver wire may be used. Copper wire is too soft and flexible for almost all articulating work, and is apt to give a green stain to bones which contain any grease, and so should be avoided. Brass tubing of various sizes is now extensively used in articulating, and for larger animals, iron supports, which will have to be made by the blacksmith specially for each subject.

However great the knowledge of the articulator, it is always best to take precautions before macerating an animal, that there should be no mistakes in arranging the bones properly, especially in the case of rare and little-known specimens. The skin and the greater part of the soft parts having been removed, and the bones roughly prepared as for a natural skeleton, should then be divided into several parts. The sternum with the costal cartilages should be removed by cutting through the latter at the junction with the ribs, and cleaned in water without macerating, and then allowed to dry in their natural form on a block of wood, cut to the requisite shape and size. If this part goes into the macerating vessel, the cartilages will be lost, and the thorax can then only be restored in an imperfect manner. The limbs should be separated, and if each is macerated in a separate vessel, much trouble will be saved in sorting the small bones of the feet. If there is any doubt about articulating them correctly, it is best to take them out before they have actually separated, and clean them off and articulate them at once, at all events drilling the holes for the wires while they are still in natural apposition. The vertebræ may be allowed to come apart and macerate together, as there is never any difficulty in placing them in their natural sequence. The hyoid bones should be sought for in the throat, and cleaned and preserved separately, and small sesamoid bones about the feet and behind the knee-joint in most animals, so commonly lost in museum specimens, should be looked for and preserved, as well as the rudimentary clavicles of the carnivora and the pelvic bones of the whales and porpoises. When the relations of any bone to another, especially of the sesamoids above spoken of, or the chevron bones under the caudal vertebræ, are likely to be lost in maceration, they should always be observed, and either notes or drawings made of them, or they should be marked with fine holes, made with an Archimedian drill (an essential instrument to the articulator). By making two holes on different bones opposite to one another before the bones are separated, or several holes arranged in patterns, most important records can be preserved, and such small holes do not damage the bones, as they can be filled up afterwards with putty, or frame-makers' composition.

[1] Lecture at the Loan Collection of Scientific Apparatus, South Kensington, July 26, 1876, by Prof. W. H. Flower, F.R.S., Conservator of the Museum of the Royal College of Surgeons of England. Continued from p. 146.